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Nonlinear Circuits and Neural Networks: Chip Implementation and Applications of the TeraOPS CNN Dynamic Array Supercomputer

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During the period July 1998 – June 1999 work has continued according to the proposed plan. Advances in research have been made in the following areas:

- The detailed test and characterization of the first-ever ARAM in the CNN Chip Set Architecture
- The constructive use of the local activity principle in designing Cellular Nonlinear Networks with complex behavior
- Analogic CNN subroutine design for various practical applications, including coding, and optical flow estimation.
- Advances in testing qualitative properties of CNN, including stability test of non-symmetric feedback CNN

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Summary

During the period July 1998 - June 1999, our work has been continued according to the proposed plan. Advances in research have been made in the following areas:

- the detailed test and characterization of the first-ever ARAM in the CNN Chip Set Architecture;
- the constructive use of the local activity principle in designing Cellular Nonlinear Networks with complex behavior;
- analogic CNN subroutine design for various practical applications, including coding, optical flow estimation, etc.;
- advances in testing qualitative properties of CNN, including stability test of non-symmetric feedback CNN

The research has been done in close cooperation with Professors Tamás Roska and Ángel Rodríguez-Vázquez and some of their co-workers.

Task 1: *The detailed test and characterization of the first-ever ARAM in the CNN Chip Set Architecture*

The analog random-access memory chip (ARAM) in a 32x256 configuration, made last year, has been tested in details, in the CNN Chip set architecture as well, and the accuracy characterization has been performed. The results explained the reasons, also on the elementary signal level, why the 7 bit precision analog accuracy, as input/output accuracy, is appropriate for visualization and detection tasks.

Task 2: *The constructive use of the local activity principle*

The local activity principle has been applied in a few important CNN types. The conditions in the CNN parameter space were determined under which complex phenomena, at the edge of chaos, could occur. These studies are useful in designing robust templates as well.

Task 3: *Analogic CNN subroutine design for various practical applications, including coding, optical flow estimation, etc*

The emergence of the more and more powerful analogic CNN Universal Machine chips makes the need for practical subroutines more and more urgent. The design of subroutines for optical flow estimation, image and video coding, shortest path finding, and locally Boolean operators were studied. It has been shown that in the latter case a special cell design could lead to a canonical solution (universal cell).

Task 4. *Advances in testing qualitative properties of CNN, including stability test of non-symmetric feedback CNN*

Some new conditions on the non-symmetric A-template for ensuring complete stability has been found. In addition explicite conditions for chaos-periodicity transitions in CNN have been determined.

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